

**LONG ISLAND WATER RESOURCES
BULLETIN 14**

**THE MEADOWBROOK ARTIFICIAL-RECHARGE PROJECT
IN NASSAU COUNTY, LONG ISLAND, NEW YORK**

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FACTORS FOR CONVERTING U.S. CUSTOMARY UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

<u>U.S. inch-pound units</u>	<u>Multiply by</u>	<u>SI units</u>
foot	0.3048	meter
gallons per day	3.785	liters per day
acres	0.4047	hectometer (hm)

THE MEADOWBROOK ARTIFICIAL-RECHARGE PROJECT IN NASSAU COUNTY, LONG ISLAND NEW YORK

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ABSTRACT

In Nassau and Suffolk Counties, where the quality and quantity of potable ground water have declined as a result of urbanization, the use of reclaimed wastewater (highly treated sewage) to replenish the ground-water supply is technically feasible. Two methods that are particularly well suited to Long Island are surface ponding of the reclaimed wastewater in basins, so that it can infiltrate to the water table, and injecting the reclaimed waste-water into the ground through wells.

At the Meadowbrook artificial-recharge project site in East Meadow, a system of 11 basins and 5 injection wells will return to the ground-water reservoir 4 million gallons per day of reclaimed wastewater, supplied by the Cedar Creek water-reclamation facilities. This demonstration project is intended to study the effectiveness of using reclaimed wastewater to replenish and improve the chemical quality of Long Island's ground-water supply. Knowledge gained in the study will have applicability to other areas where the need to conserve and augment fresh-water supplies has become critical.

INTRODUCTION

This booklet, prepared in cooperation with the Nassau County Department of Public Works, describes in nontechnical terms one approach that is being taken as a part of the water-resources management of Long Island--the recycling of reclaimed wastewater (highly treated sewage) at the Meadowbrook artificial-recharge project site at East Meadow. The booklet is a product of a continuing long-term program of water-resources studies on Long Island by the U.S. Geological Survey in partnership with municipal, county, and State agencies.

Ground water is the sole source of drinking water for the nearly 2.8 million residents of Nassau and Suffolk Counties, Long Island. In recent years, urbanization has created freshwater demands that may locally deplete the ground-water supply or severely lower the water table.

The growth of urbanization has also increased the amount of wastewater discharged to the ground through septic tanks and cesspools, and this discharge now threatens the quality of the ground-water supply. To prevent wastewater from reaching the ground-water reservoir, several sewer systems have been completed, and new ones are now being installed in parts of Long Island. The water collected by these sewer systems is piped to wastewater-treatment plants, where it is then treated and discharged to coastal waters. Although removal of wastewater through sewers protects the ground-water reservoir from sewage contamination, it threatens to accelerate the depletion of the island's ground-water supply by continually removing water that would otherwise be returned to the system. The depletion of ground water will result in a lowering of the water table, which could, in turn, diminish streamflow.

As a partial solution to this dilemma, the recycling of treated wastewater has been under intensive study on Long Island and elsewhere for more than a decade. If large volumes of the island's wastewater can be treated to meet drinking-water standards, and if the water can then be returned to the ground-water reservoir in sufficient volume, it will replenish the ground-water supply and improve its chemical quality. By preventing the water table from declining, it will also help to maintain the flow of streams.

Reclamation and reuse of water is being practiced throughout the world for a variety of purposes and in a variety of ways; some of the most significant artificial-recharge studies in the eastern U.S. have been on Long Island.

General information on the present water situation on Long Island can be found in "An Atlas of Long Island's Water Resources" (Cohen and others, 1968); a nontechnical discussion of artificial recharge on Long Island is given in "Artificial Recharge on Long Island, New York" (Aronson, 1978).

WHAT IS ARTIFICIAL RECHARGE?

Natural ground-water recharge is the replenishment of ground water by percolation of precipitation and surface water through the soil cover and earth materials to the water table. Artificial recharge may be defined as intentional replenishment of ground-water bodies.

The primary purpose of most artificial-recharge projects is to increase the amount of fresh ground water available. On Long Island, some specific objectives are to (1) compensate for recharge lost through sewerage and replace the ground water removed through pumping; (2) control or prevent the intrusion of sea water into aquifers as a result of excessive ground-water pumping near the shores; (3) maintain or raise ground-water levels to avoid increased well-construction and pumping costs; (4) dispose of treated sewage at inland sites to reduce transmission costs, and (5) dispose of storm runoff.

WHAT HAPPENS TO RECLAIMED WATER AFTER IT ENTERS THE GROUND?

To explain the mechanisms by which reclaimed wastewater enters and moves through Long Island's ground-water system, a brief description of the system is given.

Long Island is underlain by a thick, southward-dipping wedge of rock materials that consist mainly of sand, silt, clay, and gravel of glacial origin (fig. 1). These loose (unconsolidated) materials are underlain by dense, crystalline bedrock that is almost impermeable. The ground-water reservoir is within the loose materials overlying the bedrock. The surface of the ground-water reservoir is known as the water table; beneath it, the spaces between rock particles are saturated with water. Above the water table, the deposits are generally unsaturated but contain varying amounts of moisture, part of which is the soil water that supports plant life.

The rock materials that contain the ground-water reservoir can be classified into several units on the basis of (1) water-transmitting properties, (2) position in relation to other rock units or layers, (3) composition, and (4) geologic age. Units in the ground-water reservoir that yield useful amounts of water are called "aquifers" (from Latin *aqua*, water; and *ferre*, to bear). The Long Island ground-water reservoir contains four aquifers; their position and the location of major intervening clay beds, called confining beds because they retard the movement of water, are shown in figure 1.

The aquifers best suited for artificial recharge in Nassau County are the upper glacial (water-table) aquifer, which forms the land surface in most of Nassau County, and the underlying Magothy aquifer. Water from precipitation and artificial recharge moves downward through the surficial materials to the water table, where it then moves either laterally within the upper glacial aquifer or continues downward to the Magothy aquifer. Its direction and rate of movement depend on the direction of local ground-water flow and the permeability of the materials at the given area.

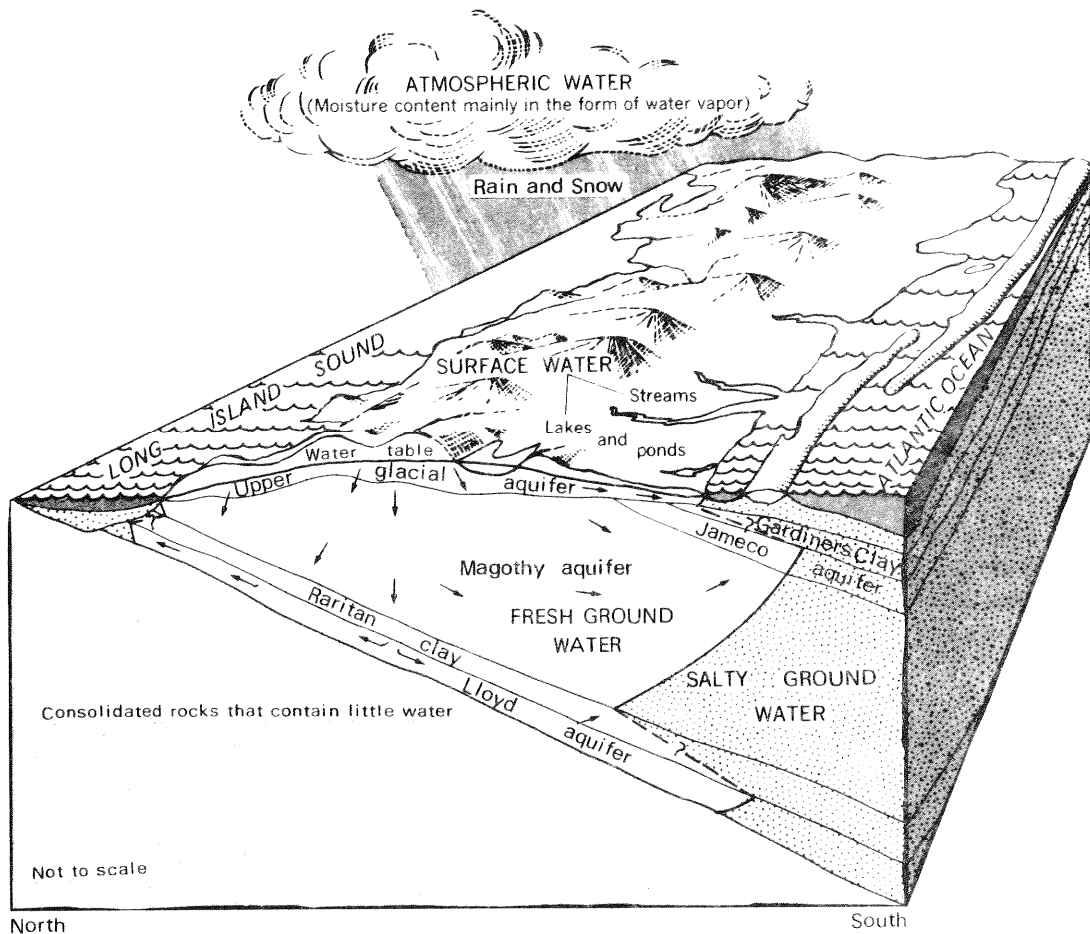


Figure 1.--Cross section of Long Island showing sources and types of water, major hydrogeologic units, and paths of ground-water flow. (Modified from Cohen and others, 1968)

WHAT IS THE MEADOWBROOK ARTIFICIAL-RECHARGE PROJECT?

The Meadowbrook artificial-recharge project is designed to evaluate methods of advanced wastewater treatment and ground-water recharge. The specific goals of the project are to:

- determine the suitability and practicality of using reclaimed wastewater for ground-water recharge on Long Island;
- determine the most efficient methods of artificial recharge;
- evaluate the physical, biological, and chemical effects of artificial recharge on Long Island's ground-water system.

Recharge operations at the Meadowbrook site will begin in 1980. The water for artificial recharge will be derived from sewage that has undergone extensive purification to meet drinking-water standards; it will be returned to the ground-water reservoir through a system of recharge basins and injection wells.

WHERE IS THE MEADOWBROOK ARTIFICIAL-RECHARGE SITE?

The Meadowbrook artificial-recharge project site is within the triangular area southeast of the intersection of Carman Avenue and Salisbury Park Drive in the Town of Hempstead (figs. 2 and 3). The site contains 35 acres and includes the Meadowbrook sewage-disposal plant, which will have ceased operation before the Meadowbrook artificial-recharge project site begins operation.

The site for the Meadowbrook artificial-recharge project was selected on the basis of several conditions, some of which are:

- (1) the land is readily available;
- (2) geologic conditions are favorable;
- (3) the distance from the Cedar Creek water-reclamation facilities to the recharge site is not prohibitive;
- (4) a nearby storm-water basin and several sewage-disposal basins at the Meadowbrook plant are available for disposal of treated water in excess of that required for project studies.
- (5) land within and surrounding the recharge site is available for installation of monitoring wells;
- (6) the water table is at sufficient depth to permit a significant mound of water to build up beneath the site.

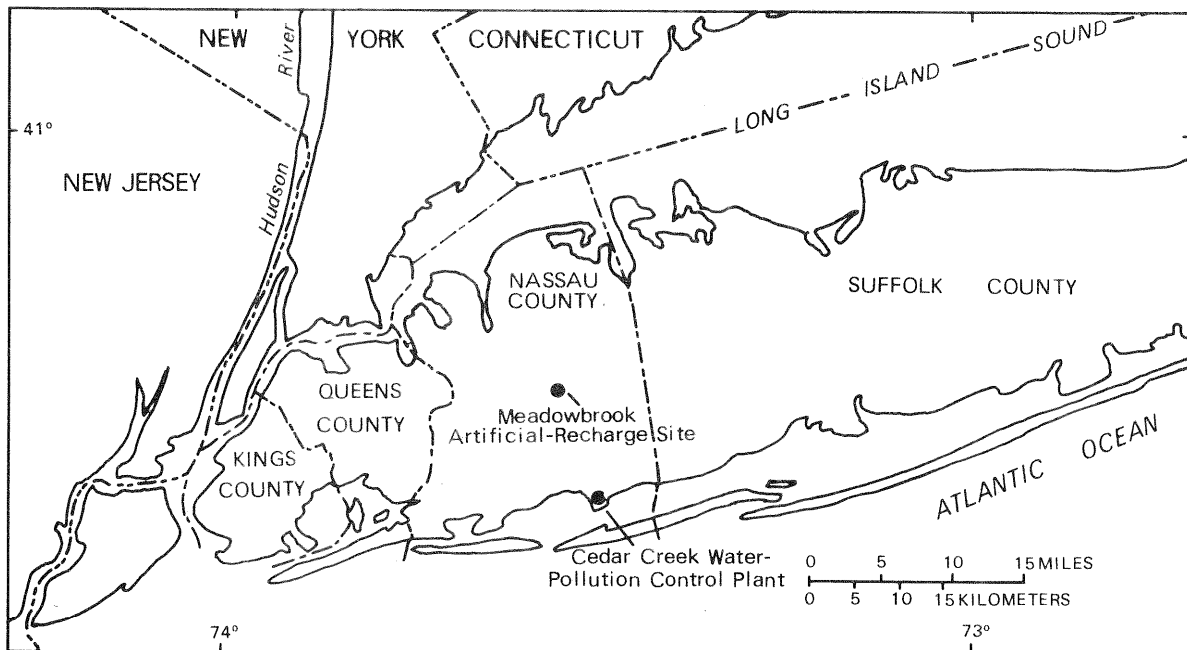


Figure 2.--Location of the Meadowbrook artificial-recharge project site and the Cedar Creek Water-Pollution Control Plant.



Figure 3.---Aerial view of Meadowbrook artificial-recharge project site showing location of injection wells, recharge basins, and the discontinued Meadowbrook sewage-disposal plant. (Looking northwest.)

WHERE WILL THE RECLAIMED WATER COME FROM?

Reclaimed wastewater will be supplied by the Cedar Creek Wastewater-Reclamation Facilities at the Cedar Creek Water-Pollution Control Plant (fig. 4). This plant is a conventional activated-sludge facility designed to treat an average flow of 45 MGD (millions of gallons per day). As much as 5.5 MGD of sewage would be diverted after screening and grit removal to serve as the influent to the Cedar Creek Wastewater-Reclamation Facilities. The remainder of the flow will receive secondary treatment before being pumped into the ocean.

The wastewater-reclamation facility consists of a 5.5-MGD advanced wastewater-treatment plant designed to produce a potable effluent suitable to return to the ground-water reservoir. The Cedar Creek Wastewater-Reclamation Facilities perform the following treatment processes:

1. Chemically assisted primary sedimentation.--Screened and degritted wastewater from the Cedar Creek Water-Pollution Control Plant is mixed with lime to remove a significant part of the phosphorus, microorganisms, suspended solids, and heavy metals.
2. Activated sludge and nitrification.--The wastewater is then piped to the activated-sludge unit, which contains recycled sludge that is rich in microbes that flourish in the presence of oxygen. This unit is heavily aerated to provide oxygen to the microbes to enable them to convert carbon compounds into water and carbon dioxide and nitrogen compounds into nitrates and water.
3. Denitrification.--The nitrified wastewater is then piped to an anaerobic unit (without dissolved oxygen), where it is treated with methanol (a type of alcohol) and recycled sludge rich in bacteria. The bacteria use the carbon in the methanol to convert nitrate to nitrogen gas, which is released to the atmosphere.
4. Chemically assisted final sedimentation.--Denitrified effluent is then mixed with alum to remove suspended solids, phosphorus, and heavy metals that were not removed previously.
5. Filtration.--The wastewater is then pumped to a dual-media (sand-anthracite) filter to remove residual suspended organic and inorganic solids.
6. Carbon adsorption.--The treated water then flows through two columns of activated carbon to remove remaining dissolved organic substances.
7. Chlorination.--The treated water undergoes final chlorination to destroy residual microorganisms.

The reclaimed wastewater produced by the Cedar Creek Wastewater-Reclamation Facilities will then be tested before it is pumped 6.25 miles north to the Meadowbrook artificial-recharge project site.

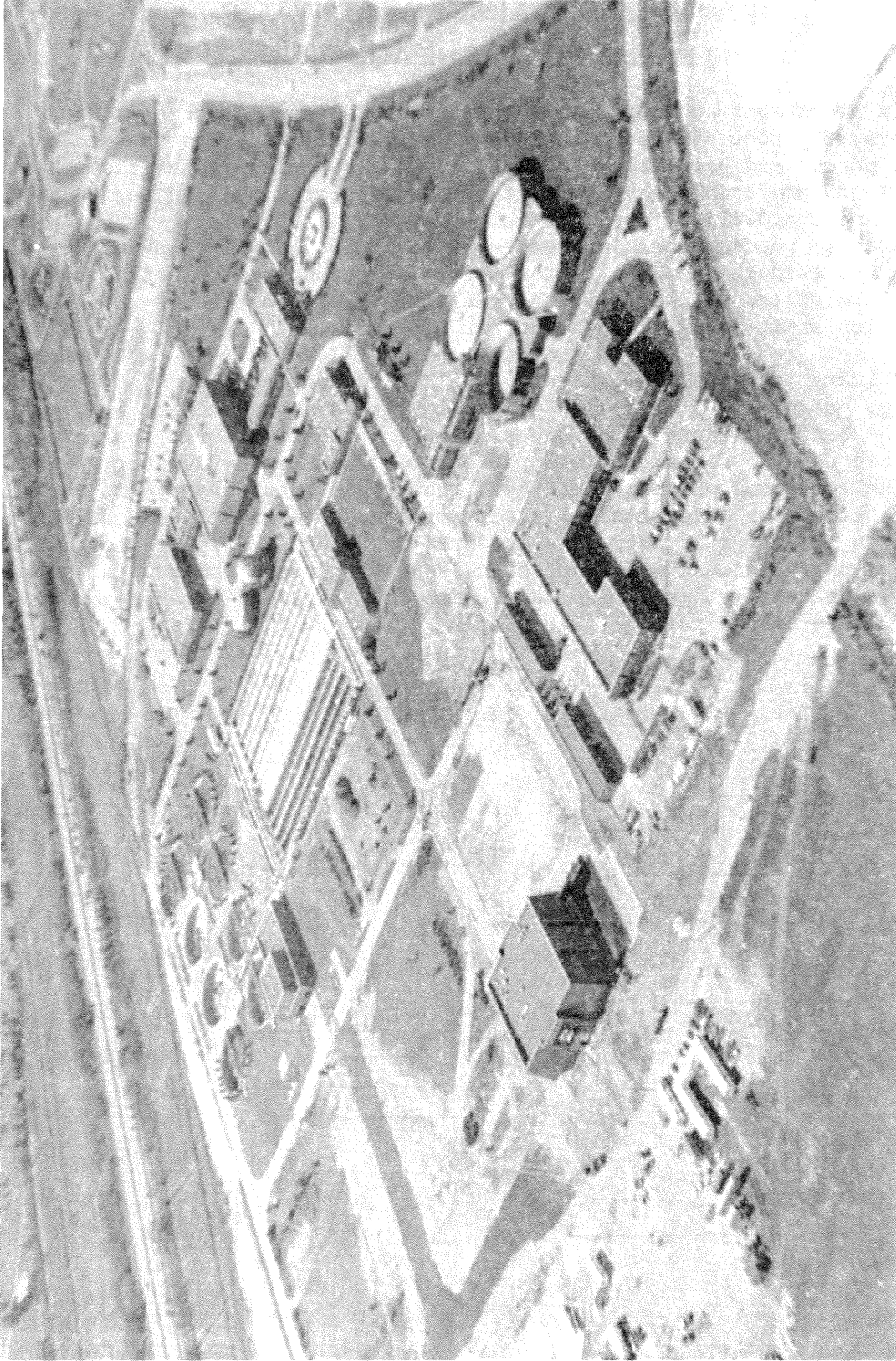


Figure 4.--Aerial view of Cedar Creek Water-Pollution Control plant. (Looking northwest.)

HOW WILL RECLAIMED WASTEWATER BE RETURNED TO THE AQUIFER?

In areas such as Long Island that are underlain by unconsolidated deposits, the most efficient methods of artificial recharge take advantage of the porous and permeable character of the subsurface materials. Two methods of artificial recharge that are particularly well suited to Long Island and that will be used at the Meadowbrook artificial-recharge project site are (1) ponding reclaimed water on the land surface to permit it to infiltrate through the soil to the water table; and (2) injecting reclaimed water into wells. Either way, the reclaimed water is further purified by filtration as it moves through aquifer materials.

Primary recharge facilities at the Meadowbrook site consist of 11 recharge basins and 5 injection wells (layout is shown in fig. 5). Water from the basins recharges the upper glacial aquifer, whereas the injection wells are used to recharge the upper part of the Magothy aquifer (fig. 6). When the reclaimed wastewater reaches the ground-water reservoir, whether through basins or injection wells, it moves both vertically and horizontally away from the point of entry, as depicted in figure 6. Thereafter, it mixes with the native ground water and moves seaward through the aquifer system until it eventually discharges to streams, the bays and ocean, or to water-supply wells on the island (fig. 6).

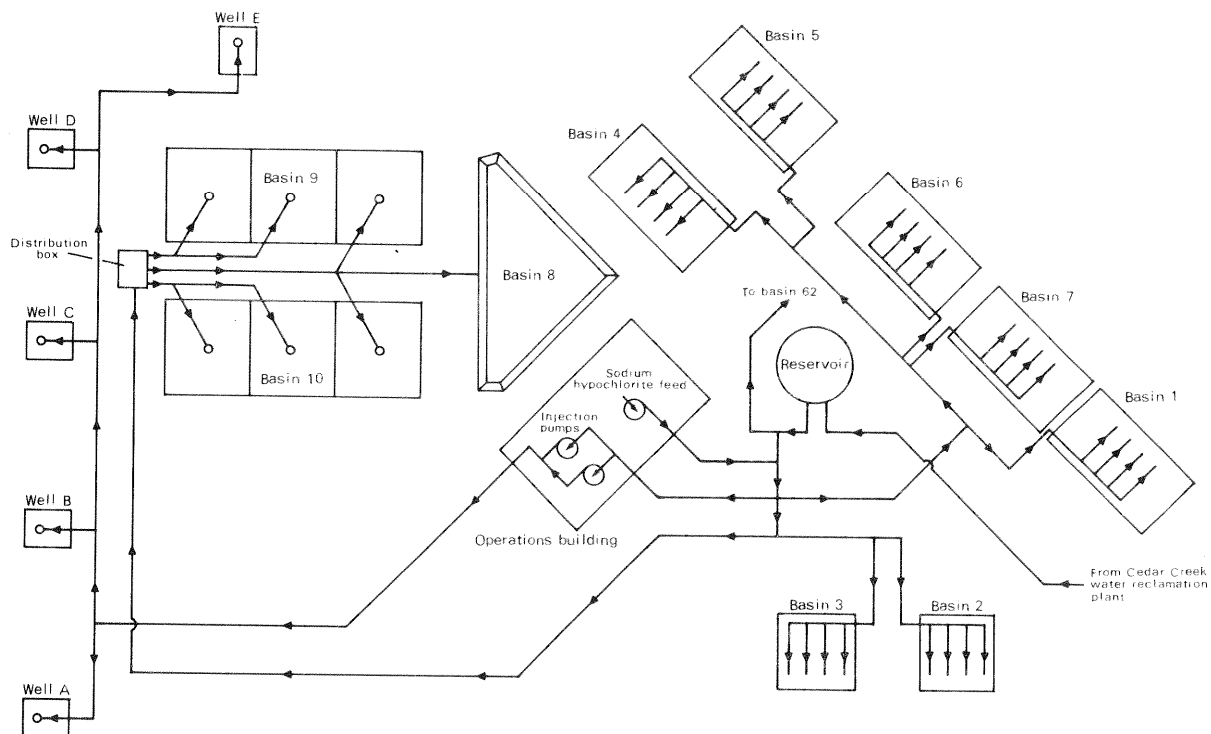


Figure 5.--Schematic diagram of Meadowbrook artificial-recharge project site showing relative location of recharge basins, injection wells, and water-transmission mains. (Modified from Consoer, Townsend, and Associates, 1978)

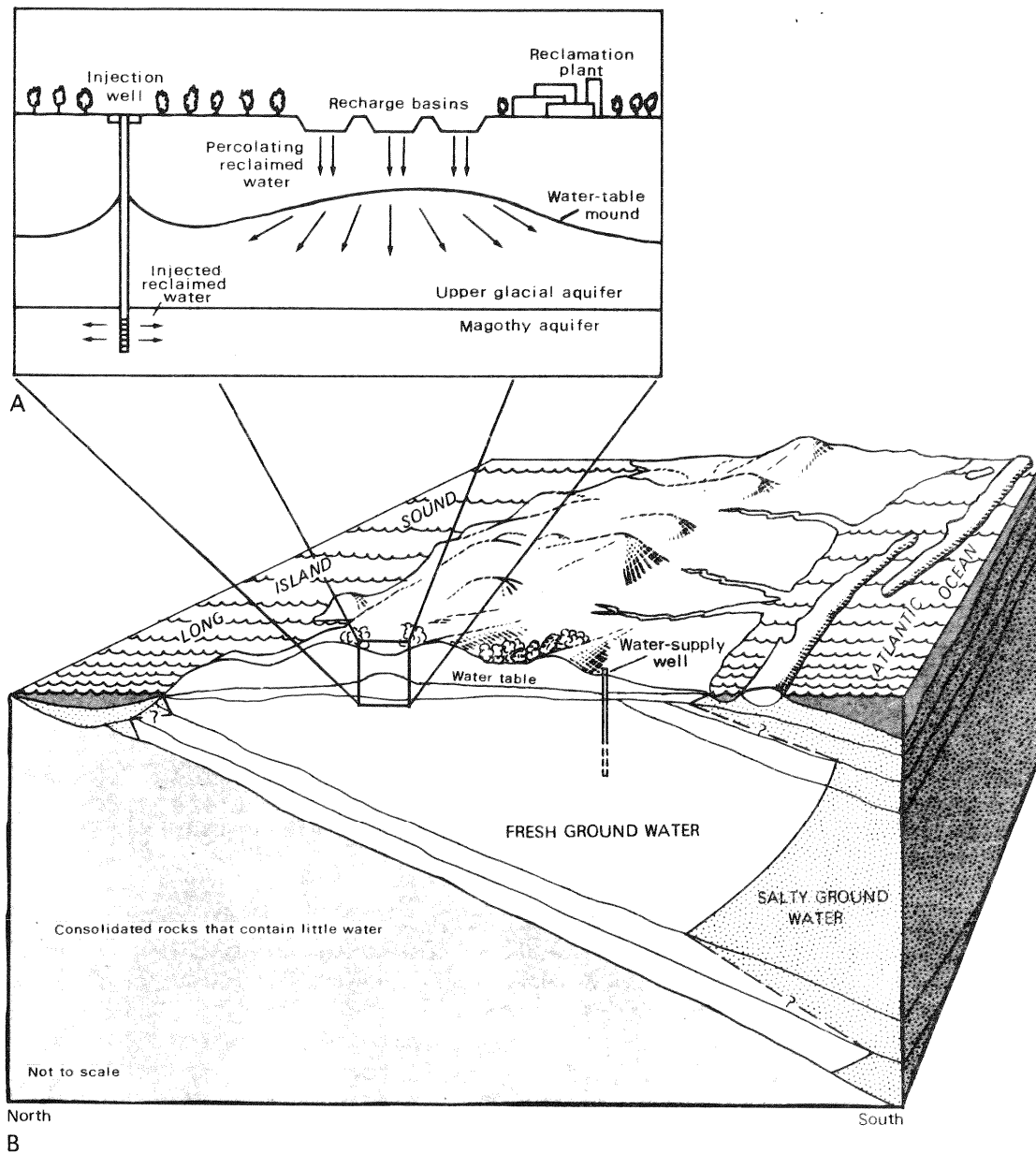


Figure 6.--Cross section of Long Island showing (A) water-table mounds that develop beneath a recharge basin and above an injection well during recharge, and (B) flow directions of reclaimed water from recharge site. (Modified from Cohen and others, 1968)

WHAT ARE RECHARGE BASINS AND HOW WILL THEY OPERATE?

In general, recharge basins are open pits of various shapes and sizes, excavated in permeable sand and gravel deposits, in which water is ponded to allow infiltration. Artificial recharge by ponding of water in basins is well suited to Long Island, as demonstrated by more than 2,200 storm-water basins that, since their inception in 1934, have effectively disposed of many billions of gallons of storm runoff.

Of the 11 recharge basins at the Meadowbrook site, 10 are specially constructed for the infiltration of reclaimed water; the 11th is a storm-water basin. The locations of the 11 basins are shown in figure 5. About 2 MGD will be infiltrated through those basins over a 3-year period.

Basins 1-7

The shallow basins (numbered 1 through 7 in fig. 5) are 5 feet in depth. These basins will be studied intensively to evaluate (1) which procedures are most effective in maintaining high recharge rates; (2) causes of clogging of the basin floor during ponding of reclaimed wastewater, and (3) the ability of the unsaturated zone (the sand and gravel deposits that lie between the basin floor and the water table) to improve the quality of percolating reclaimed wastewater by filtration. A view of basin 3 is shown in figure 7.

The high cost and limited availability of land in Nassau County require that a high infiltration rate be maintained to provide efficient land use. Previous studies have shown that infiltration rates at ponding sites tend to decline with time, regardless of the purity of the reclaimed wastewater. Decreases in infiltration rate can be attributed to (1) swelling of soil particles after wetting, (2) clogging of the soil pores with organic slimes or chemical precipitates produced by microbial activity, and (3) particles that are intercepted at the soil surface.

Where the flow of reclaimed water into the soil and to the water table is slowed, soil treatments and other procedures can be applied to increase soil permeability and recharge rates. Some procedures used on Long Island to maintain high infiltration rates include (1) alternating a period of water ponding with a period of drying out (an application-and-rest cycle); (2) tilling or scarifying (scraping) a basin floor that has become clogged by detritus or microbial activity; (3) ponding the reclaimed water deeply to increase pressure at the ponding surface; (4) mulching the soil to increase porosity and permeability; (5) covering the fine-grained native material on the floor of the basin with gravel to disperse clogging materials, and (6) planting vegetation on the infiltration area to increase soil porosity and permeability and to provide root channels through which water can percolate.

The procedures to be tested at basins 1-7 are summarized in table 1. These practices represent a variety of application-and-rest cycles as well as several methods for promoting infiltration and dispersing clogging materials that may accumulate or form at or near the basin floor during ponding.

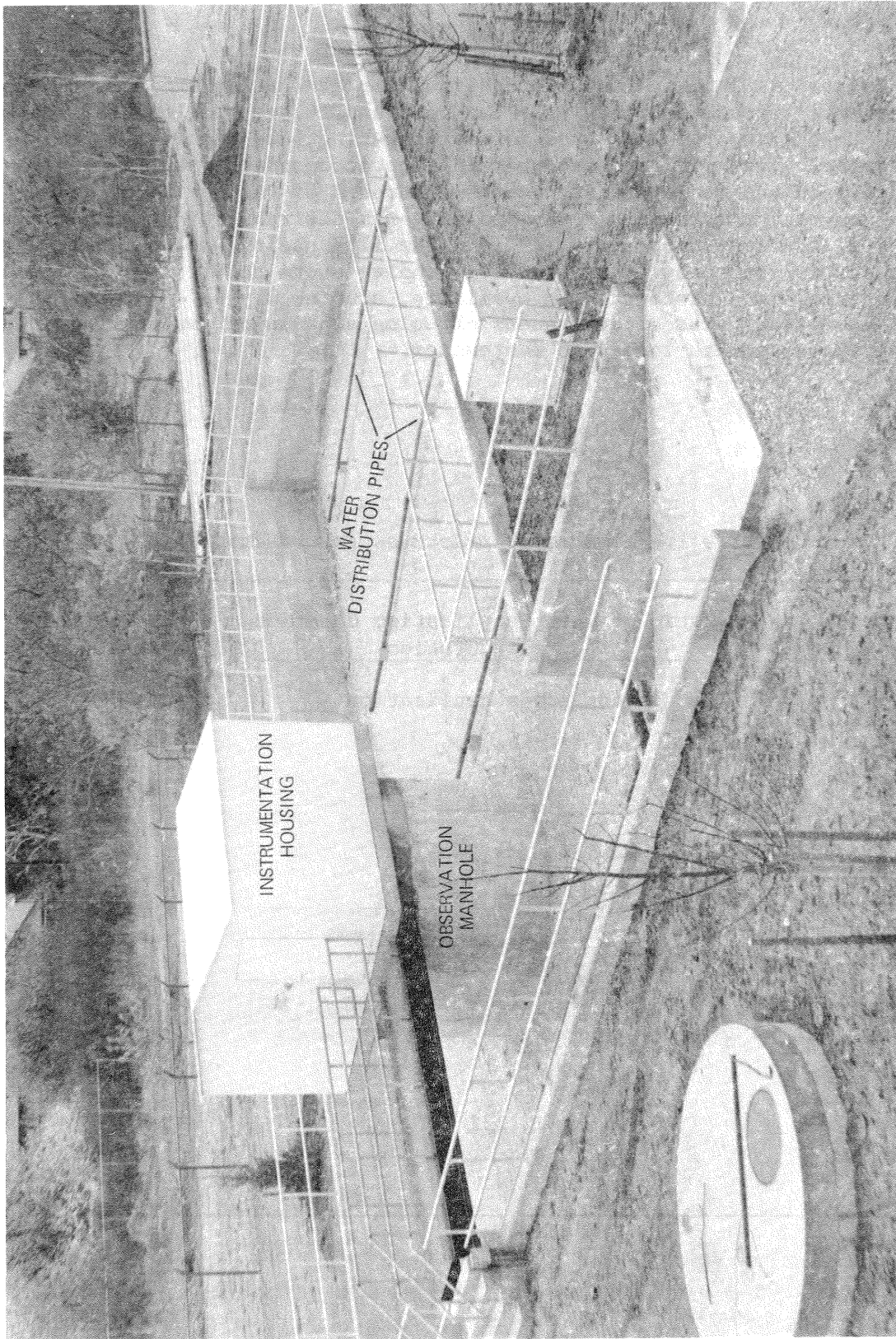


Figure 7.--Recharge basin 3.

Basins 8-11

Basin 8 is a 15-ft-deep pit designed for evaluating the effectiveness of recharge through deep basins. Basins 9 and 10 are shallow, 5-ft-deep basins that were originally used for infiltrating less highly treated wastewater. They will be used primarily to accommodate water in excess of that required for operating basins 1 through 8. As the study proceeds, data from basins 1 through 8 may indicate the desirability of running supplemental studies in basins 9 and 10. The 11th basin, Nassau County Recharge Basin 62, is currently being used for ponding storm runoff. Whenever sufficient reclaimed wastewater is available, studies may be conducted in this basin to evaluate the effectiveness of using stormrunoff basins for supplemental recharge with reclaimed wastewater.

Table 1.--Management practices for basins 1-7

<u>Basin Number</u>	<u>Ratio of water-application duration to rest duration</u>	<u>Basin-floor treatment</u>
1	continuous application	None
2	2:1	None
3	1:2	None
4	1:1	None
5	1:1	Cleaned and cultivated during rest period
6	1:1	Layer of pea-sized gravel spread on basin floor
7	1:1	Seeded to grass (such as Reed canary grass)

WHAT ARE INJECTION WELLS AND HOW WILL THEY OPERATE?

Injection wells are similar to water-supply wells in construction but have the opposite purpose. Water-supply wells are used to draw water from an aquifer to land surface, whereas injection wells are used to pump water from land surface into an aquifer (see figs. 8 and 9.) A major phase of the Meadowbrook artificial-recharge project involves the injection of reclaimed water through a system of five shallow wells. (Locations are shown in figure 5).

Four injection wells will be in operation at any given time, with one on standby. Each well will inject 0.5 MGD (350 gallons per minute) of reclaimed wastewater, so that four together will inject 2 MGD. Four of the wells are approximately 100 feet deep and consist of fiberglass-reinforced epoxy casing, 65 feet in length and 1 foot in diameter, above a stainless-steel, wire-wrapped screen 30 feet in length and 1 foot in diameter. A stainless-steel sand trap, 5 feet in length, is attached to the bottom of the screen (fig. 10). The fifth well is about 135 feet deep and has a 40-foot sand trap. In three of the 100-foot wells and in the 135-ft well, the space between the screen and the surrounding sand and gravel deposits is filled with a "gravel pack" of fine gravel. The fifth well was constructed without a gravel pack; that is, the well screen is in contact with the surrounding sand and gravel deposits that, in effect, form a natural gravel pack (fig. 10). This well will permit comparison of the operating efficiency of a natural-pack well with artificial-pack wells. In general, a gravel pack provides for a larger surface area over which clogging materials in the injected water may be distributed and thereby helps to maintain high rates of recharge over a longer period of time. In this respect, the gravel pack of a well acts in a similar way and for the same purpose as a gravel cover on the floor of a recharge basin.

When the injection wells become partly clogged, largely by particles borne in the reclaimed water, they will be heavily pumped in the reverse direction to dislodge the clogging material and thereby restore their injection capability. This procedure, called the redevelopment process, insures at least partial restoration of the original recharge rate. It also provides further advantages, namely that the pumping equipment used in redevelopment permits hydraulic testing of both the injection well and the aquifer before and after injection of reclaimed water and also facilitates sampling of water from the aquifer for chemical, microbiological, and particle-size analyses.



Figure 8.--Vault housing injection well B.

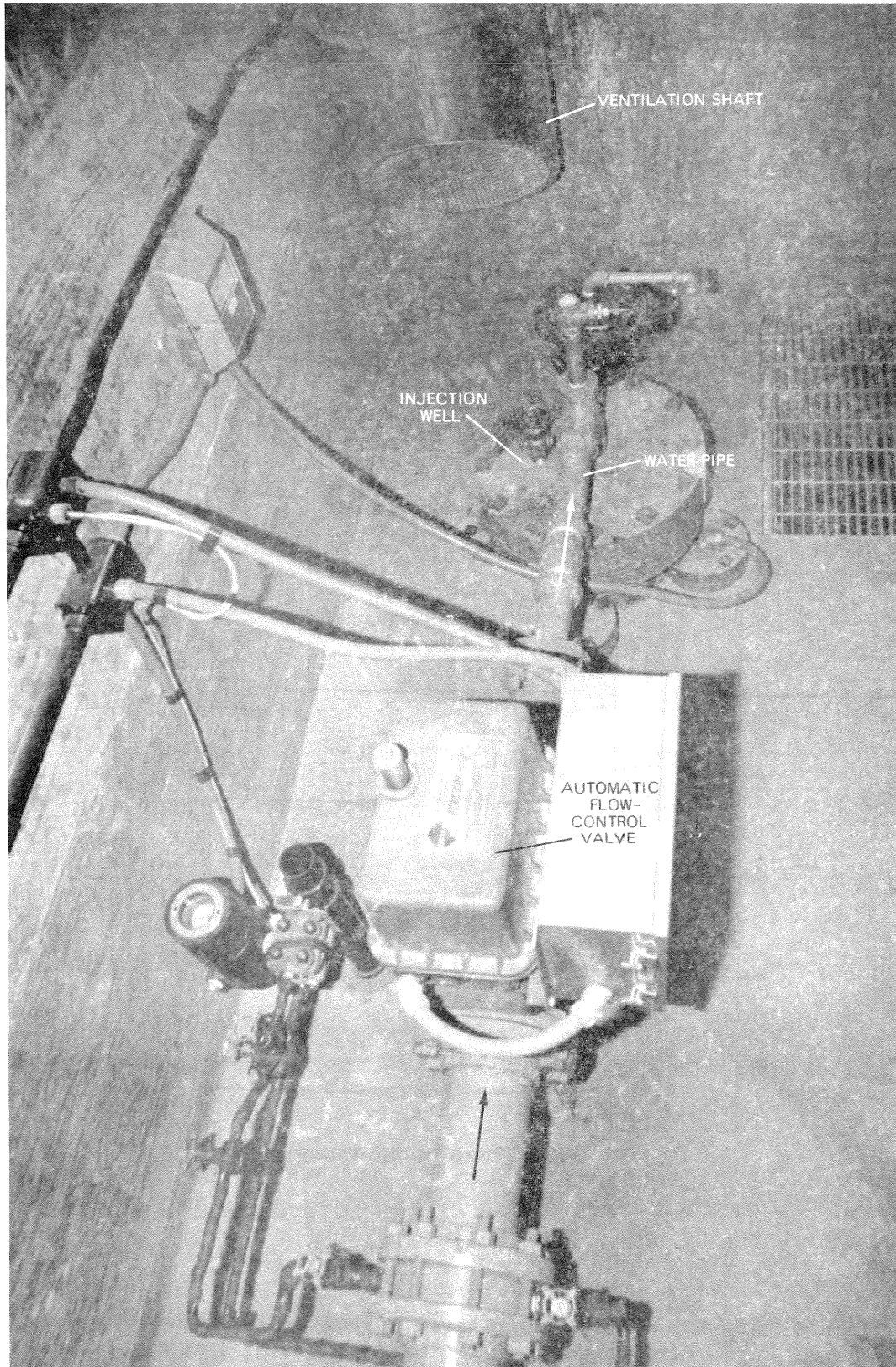


Figure 9.--Interior of vault housing injection well B.

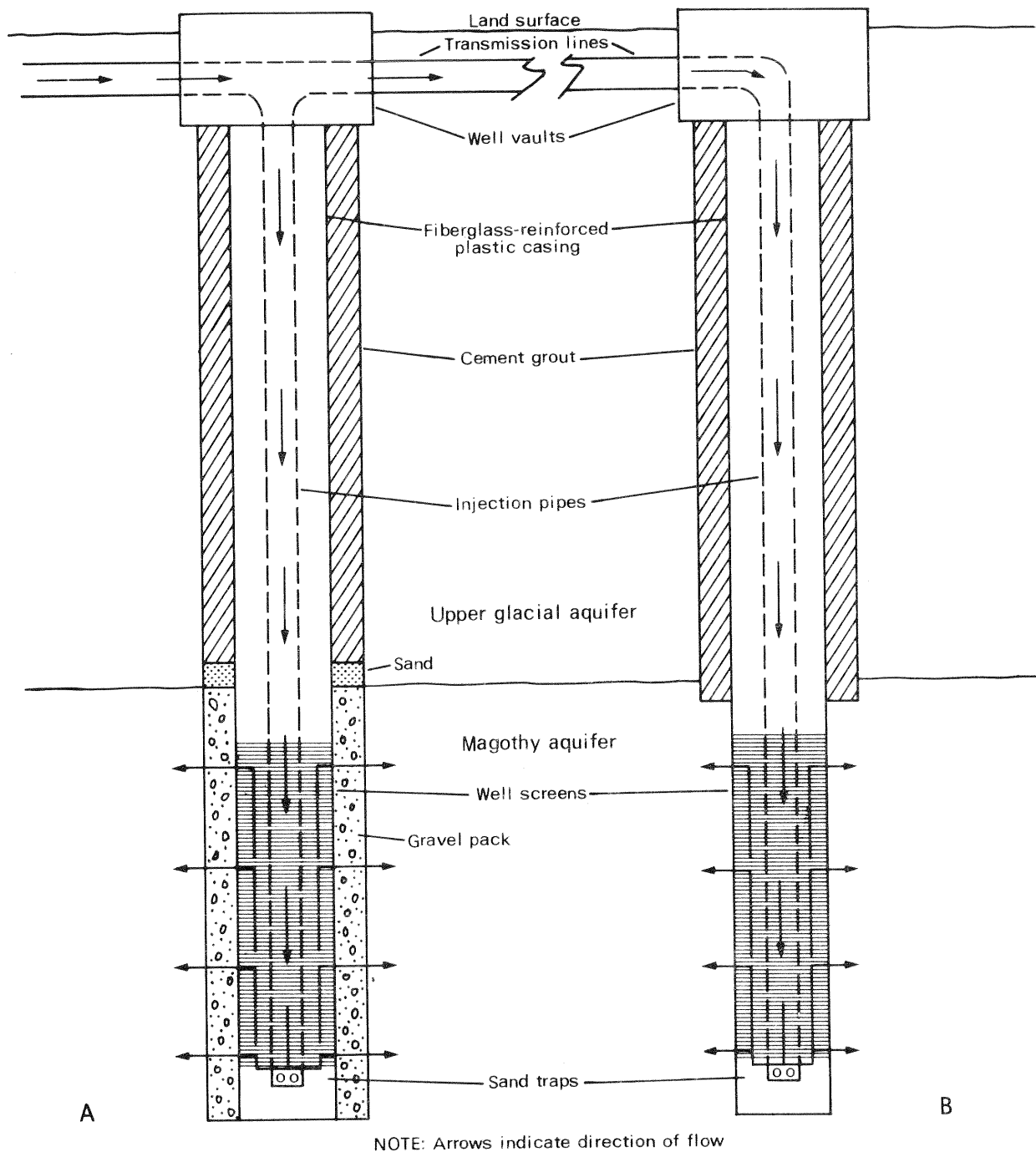


Figure 10.--Generalized cross sections of wells having (A) artificial gravel pack, and (B) natural gravel pack, at Meadowbrook artificial-recharge project site.

WHAT SAFEGUARDS WILL BE TAKEN DURING ARTIFICIAL RECHARGE?

The widespread acceptance of wastewater reclamation and artificial recharge can be attributed in large part to the growing public awareness of the need for conservation of natural resources and the preservation of environmental quality. Thus far, no adverse health effects have been associated with this practice in the United States. Nevertheless, the public must be assured that Cedar Creek Wastewater-Reclamation Facilities and Meadowbrook artificial-recharge project site are designed and operated to produce reclaimed water that will introduce no harmful substances into the ground-water reservoir. Accordingly, prudent management of the artificial-recharge project will require many safeguards and monitoring systems.

Wastewater Disposal

One desirable safety feature for any artificial-recharge project is an alternative method of disposal when the quality of reclaimed water is unacceptable for recharge or when the water is not needed. To this end, the Cedar Creek facility has been designed so that the flow of reclaimed water to the Meadowbrook site can be diverted to the ocean.

Water Quality

The reclaimed wastewater used in the artificial-recharge project will be continually sampled to insure that it meets Federal and State chemical, biological, and physical standards so that no harmful substances will be introduced into the ground-water reservoir. In addition, ground water near the recharge basins and injection wells and at selected distances therefrom will be monitored to detect any unfavorable chemical reactions between reclaimed water and the native ground water and to trace the course of the reclaimed water as it moves through the ground-water system.

Water-Table Altitude

Monitoring the water-table rise during artificial recharge is necessary to determine (1) the magnitude and areal extent of water-table mounds that develop beneath the recharge sites, (2) the degree of regional water-table rise to prevent flooding in areas where the water table is close to land surface, and (3) the direction and degree of ground-water flow before, during, and after recharge.

Streamflow and Stream Quality

When the ground-water reservoir is recharged with reclaimed wastewater, the water table can be expected to rise locally, which may increase stream length and flow, and may also affect stream quality. Therefore, nearby streams will be monitored to evaluate increases in flow and length as well as changes in water quality that may occur.

SUMMARY

In Nassau and Suffolk Counties on Long Island, the ground-water supply has been gradually diminished by the demands of continued population growth and by the increase of sewerage, which shunts wastewater and storm runoff to coastal waters. More important, the quality of ground water is threatened locally by infiltration from septic tanks, cesspools, and industrial effluents, and, near the shore, by saltwater intrusion induced through heavy pumping for public-water supply.

It is technically and economically feasible to replenish the Long Island ground-water supply with highly treated wastewater (reclaimed water). Two methods that are particularly well suited to Long Island are surface ponding of reclaimed wastewater in basins for infiltration to the water table and injection of reclaimed wastewater through wells. Beginning in 1980, a system of 11 basins and 5 injection wells will return to the ground-water reservoir 4 MGD of reclaimed wastewater, supplied by the Cedar Creek Wastewater-Reclamation Facilities, at the Meadowbrook artificial-recharge project site in East Meadow, Nassau County.

A probable hindrance to recharge through basins and wells at the Meadowbrook site is clogging of the infiltration surface of basins and wells by suspended particles in injected water. Infiltration rates of basins, and injection rates of wells, can be maximized by proper maintenance and management practices and by suitable treatment of the reclaimed wastewater before recharge.

The success of the Meadowbrook artificial-recharge site will depend, in large part, on the quality of the reclaimed wastewater produced by the Cedar Creek Wastewater-Reclamation Facilities. Adverse effects of artificial recharge can be minimized by monitoring (1) chemical and microbiological quality of reclaimed water before it is injected or ponded and the quality of the native ground water in the recharge area; (2) water-table levels as they rise in response to recharge; and (3) changes in volume and chemical quality of streamflow near the recharge site.

Municipal consumption of water on Long Island is expected to increase in the near future in response to growth of population and industry. Thus, it can be expected that withdrawals from Long Island's ground-water reservoir will increase, that sewerage will be expanded and will reduce recharge further, and that the need for additional sources of usable ground water will be intensified in years to come. The Meadowbrook artificial-recharge project is intended as a demonstration project for the use of reclaimed wastewater to replenish and improve the quality of the ground-water reservoir. Results of the study will have applicability to other parts of the world where the need to conserve and augment freshwater supplies has become critical.

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